

Butterfly counts at Casuarina Coastal Reserve in the seasonal tropics of northern Australia

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Abstract

Seasonal rhythms underlie most ecological phenomena, but the seasonality of butterfly assemblages in the monsoonal tropics of the Top End of northern Australia remains unquantified. I counted butterflies along a 2.9-km transect through the Casuarina Coastal Reserve near Darwin in northern Australia on 23 occasions during eight census periods over a 14-month period. Both the number of taxa and number of individuals peaked during the wet season, but the latter peak continued into the early dry season. The dry season troughs in activity were about 50% by taxa and 35% by number compared with wet season peaks. Eight taxa demonstrated clear seasonal peaks, four in the wet season, two in the late wet – early dry season and two in the dry season. Much remains to be learnt about the seasonality of butterflies in the Australian monsoon tropics.

Introduction

In highly seasonal environments, organisms that live for less than a year, such as most butterflies (Lepidoptera: Papilionoidea, Hesperioidea), may not be able to breed continuously. If they cannot, they must vary their life history among generations, with some stage undergoing diapause – a state of rest or reproductive inactivity. For example, adults of the Common Crow *Euploea corinna* enter reproductive diapause during the tropical dry season, aggregating in sheltered refugia (Monteith 1982) until new growth is available on their larval food plants (Canzano *et al.* 2003). In the seasonal tropics, considerable attention has been given to adult diapause as a mechanism for coping with the dry season (e.g. Jones & Rienks 1987; Braby 1995a; Pieloor & Seymour 2001; Canzano *et al.* 2006). However, there is limited literature on egg, larval or pupal diapause in the tropics, even though adults of some species are absent during the dry season (e.g. Hill 1999; Braby *et al.* 2010). Common and Waterhouse (1981) report pupal dormancy in Darwin populations of the Fuscous Swallowtail *Papilio fuscus* that may last for more than two years. Diapause has been documented in each life stage (egg, larvae, pupae, adult) in temperate-zone butterflies (Scott 1981 cited in Ehrlich 1988).

More generally, the seasonality of butterfly assemblages has been poorly documented in the seasonal tropics, including monsoonal northern Australia, and no clear general patterns are apparent. In less seasonal tropical areas, butterfly species richness and/or abundance may peak in the dry (Borneo – Hamer *et al.* 2005; north Queensland – Braby 1995b) or wet season (Brazilian Atlantic forest: Ribeiro *et al.* 2010), whilst in more intensely seasonal environments, there are reports of no seasonal peak (Brazilian cerrado – Pinheiro *et al.* 2002) or a peak in the wet season (Mexican tropical dry forests – Luna-Reyes *et al.* 2008, 2010).

In this paper, I present count data for butterflies at eight intervals over a 14-month period in the Casuarina Coastal Reserve near the city of Darwin in northern Australia. The Darwin area is warm to hot throughout the year. The mean annual rainfall of 1,700 mm includes an extended dry season in which rainfall is typically negligible for 5–7 months and often zero for 3–5 months (McDonald & McAlpine 1991).

Methods

Butterflies were censused using a “Pollard walk” (Pollard 1977). This is a fixed-width (line or strip) transect, as also employed extensively for the census of birds (Bibby *et al.* 1992), in which the observer walks at a slow, steady pace along a pre-determined line and counts butterflies within a fixed distance of the line. The method necessarily documents diurnal species and especially those that are active at the time of day the count is conducted and those that fly low, but is excellent for detecting common species even in closed forest environments (Sparrow *et al.* 1994).

In this study, a single transect 2.9 km-long was employed. The transect formed a loop through a range of habitats in the Casuarina Coastal Reserve (12°21'S, 130°53'E), Darwin, following either established walking trails or the mown grassy edge to coastal vine-forest. The habitats sampled were:

- coastal vine-forest (the group 9, “semi-deciduous rain forests and vine thickets associated with a variety of well to excessively drained coastal and subcoastal landforms” of Russell-Smith (1991)) – 0.4 km;
- the ecotone between coastal vine-forest (as above) and mown dune grassland – 1.0 km;
- mangroves – 0.3 km;
- savanna woodland dominated by *Eucalyptus tetrodonta* and *Terminalia ferdinandiana* with a mostly perennial-grass understorey – 0.8 km; and
- parkland with mown exotic grasses and forbs and scattered remnant trees – 0.4 km.

None of the transect was subject to artificial watering, and the only natural external source of moisture in the dry season is tidal inundation of mangroves. Most of the savanna woodland was burnt in both years of the study.

Transect counts were conducted during eight periods, hereafter 'census periods', over a 14-month period from late July 2008 to late September 2009. Three transect 'counts' were undertaken in each census period (2 only in the 4th census period, Jan. 2009). The median (range) of intervals between census periods (median date of counts) was 57 (49–76) days and between counts within census periods was 7 (2–33) days.

Counts were conducted only on days with >50% sunshine during the late morning, no rain and at most a light breeze. I commenced counts between 1000 and 1030 h and they lasted 1.5 – 2 h including stoppage time to identify butterflies located whilst walking – butterflies were not counted if encountered only during stoppage time. With consecutive counts I alternated the direction of walk along the loop. Butterflies within or above a 5 m half circle in front of the observer were counted. At this distance (and without the use of net or optical aid) it was not possible to consistently identify all species so where necessary, species were aggregated into genera and morphotaxa, 29 of which were recognised (Appendix). For simplicity of terminology, the species, genus or morphotaxa recognised are hereafter referred to simply as 'taxa', names given to morphotaxa being presented in inverted commas.

Seasonal patterns were identified graphically after statistical screening. To evaluate the ability of the data to identify seasonal patterns, the number of species, number of butterflies, and number of each taxon present in 5 or more counts were compared across census periods with counts as replicates using non-parametric Kruskal-Wallis tests. Graphical results are presented only where the tests indicated significant differences among census periods with a probability less than 0.05.

Variation in assemblage composition among census periods was examined by Non-Metric Multidimensional Scaling in the software PC-Ord 4.01 (McCune & Mefford 1999). For each census period, 1 averaged counts of taxa. The six taxa present in only one census period were excluded. Mean counts of the remaining taxa were $\ln(x+1)$ -transformed to moderate the influence of a few abundant species. I employed the Bray-Curtis distance measure and allowed up to 400 iterations to ensure stable results. Fifty Monte Carlo runs in each of from 1–6 dimensions were used to generate stress from random data for comparison with stress from ordination results in a scree plot; this provided a quantitative basis for selecting the optimal dimensionality with which to present results.

Larval food plants were summarised into growth forms (herbaceous – grass, forb, vine; woody – shrub, tree, vine) for each taxon from information in Braby (2000). These are presented for all taxa in the Appendix and summarised in Table 1.

Table 1. Evidence of variation in the number of butterfly taxa, the number of butterflies, and the numbers of individual taxa that were present in more than five counts among eight census periods, along with larval food plant types for taxa. Definitions of morphotaxa are in the Appendix. Food plant types are generalised from the Appendix into the following categories: herbaceous (herb.) – grass, forb, vine; woody – shrub, tree, vine. * indicates $P < 0.05$; ** $P < 0.01$.

Response variable	Food plant type	No. of counts present (of 23)	Kruskal-Wallis H	Probability
No. of taxa		23	17.5	0.01 *
No. of butterflies		23	15.3	0.03 *
Hesperiidae				
"grass-darts" (Hesperiidae part)	grass	7	14.7	0.04 *
Papilionidae				
Fuscous Swallowtail (<i>Papilio fuscus</i>)	shrub	6	17.8	0.01 *
Pieridae				
Lemon Migrant (<i>Catopsilia pomona</i>)	tree	17	15.5	0.03 *
grass-yellows. (<i>Eurema</i> spp.)	forb & woody	20	18.1	0.01 *
Small Pearl-white (<i>Elodina walkeri</i>)	woody vine	23	15.0	0.03 *
"gull / albatross" (Pieridae part)	woody mixed	21	17.2	0.02 *
Nymphalidae				
Orange Ringlet (<i>Hypocysta adiante</i>)	grass	16	10.8	0.15
Orange Lacewing (<i>Cethosia penthesilea</i>)	woody vine	10	13.7	0.06
Varied Eggfly (<i>Hypolimnas bolina</i>)	forb	8	11.1	0.14
Blue Argus (<i>Junonia orithya</i>)	forb	6	13.3	0.07
Meadow Argus (<i>Junonia villida</i>)	forb	9	17.2	0.02 *
Lesser Wanderer (<i>Danaus petilia</i>)	woody vine	7	12.5	0.08
Swamp Tiger (<i>Danaus affinis</i>)	woody vine	18	20.1	0.005 **
Small Brown Crow (<i>Euploea darchia</i>)	woody vine	10	17.2	0.02 *
Common Crow (<i>Euploea corinna</i>)	woody mixed	23	15.8	0.03 *
Lycaenidae				
"small shrub lycaenids" (Lycaenidae part)	woody mixed	22	17.5	0.01 *
"small grass lycaenids" (Lycaenidae part)	herbaceous mixed	16	19.7	0.006 **

Results

Both the number of taxa and number of individuals varied significantly over time (Table 1, Figure 1). The number of taxa varied two-fold, peaking during the wet season. The number of butterflies varied three-fold and also peaked in the wet season, though the peak was later than for species richness and continued into the early dry season. A dramatic but variable increase in the number of butterflies in September 2009 was attributable to irruptions of “gull / albatross” (mostly Caper White *Belenois java*) and “small shrub lycaenids” (believed mostly to be the Purple Cerulean *Jamides phaseli* associated with the flowers of *Millettia pinnata*).

Of the 17 taxa present in more than five counts, changes over time were demonstrable in 12 (Table 1), which is markedly more than the 5% that can be attributed to chance. Of these, four taxa peaked during the wet season (“grass-darts”, Fuscous Swallowtail, Meadow Argus, “small grass lycaenids”), two in the dry season (Swamp Tiger, “small shrub lycaenids”), and two in the mid-wet to early-dry season (grass-yellows, Small Brown Crow). The remaining four species displayed more diffuse patterns with no consistent trend (Lemon Migrant, Small Pearl-white, “gull / albatross”, Common Crow) (Figures 2, 3).

Interpretation of butterfly assemblages in a single dimension was the optimal outcome from ordination (Figure 4). Assemblages dichotomised on the basis of the wet and dry season, with a particularly large difference (2.16 of max. difference of 3.02) between consecutive census periods from 30 September to 20 November 2008.

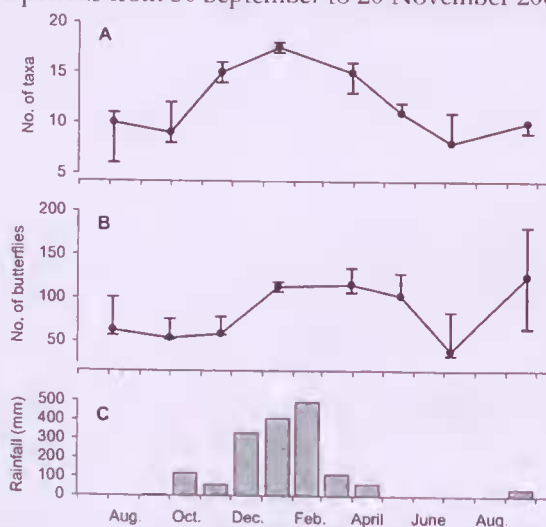


Figure 1. Variation over time from July 2008 to Sept. 2009 in: (A) the number of taxa/morphotaxa counted in Casuarina Coastal Reserve; (B) the number of butterflies counted in Casuarina Coastal Reserve; and (C) rainfall recorded during the study period at Darwin Airport. Data points in A and B are medians \pm range.

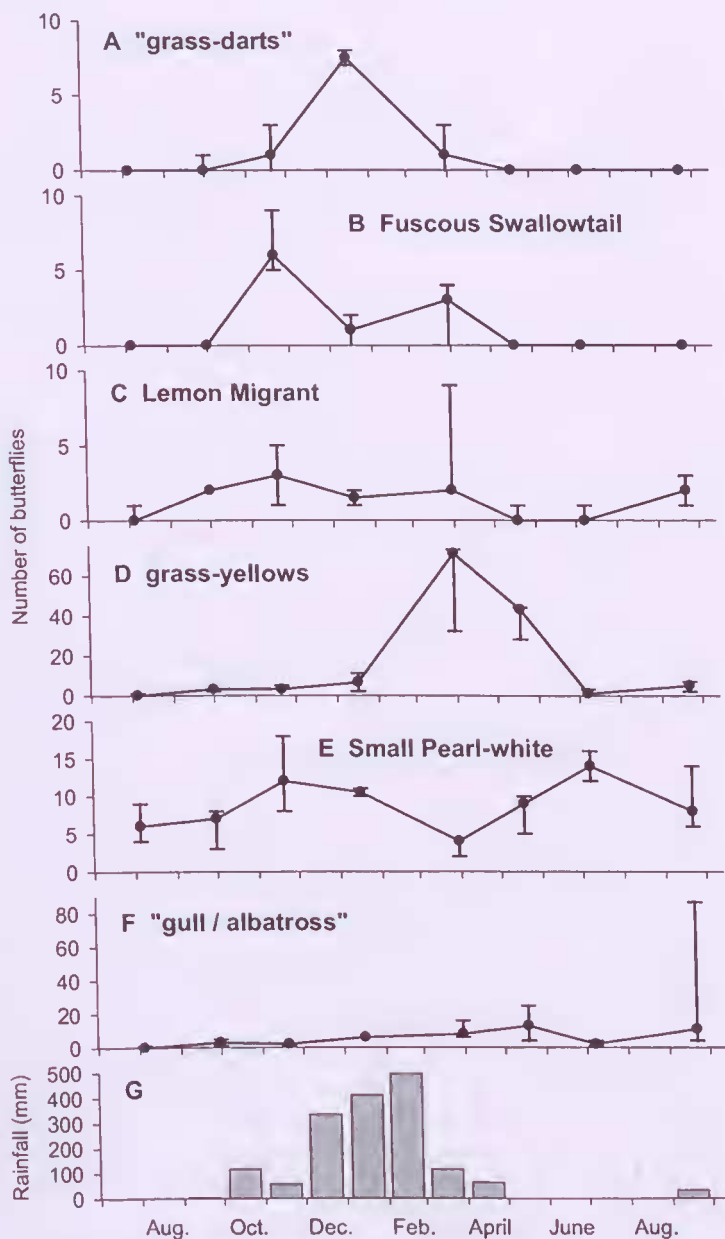


Figure 2. Variation over time in numbers (median \pm range) of six butterfly taxa: (A) Hesperidae; (B) Papilionidae; (C-F) Pieridae at Casuarina Coastal Reserve; and (G) rainfall at Darwin Airport from July 2008 to Sept. 2009. Note varying scales of abundance.

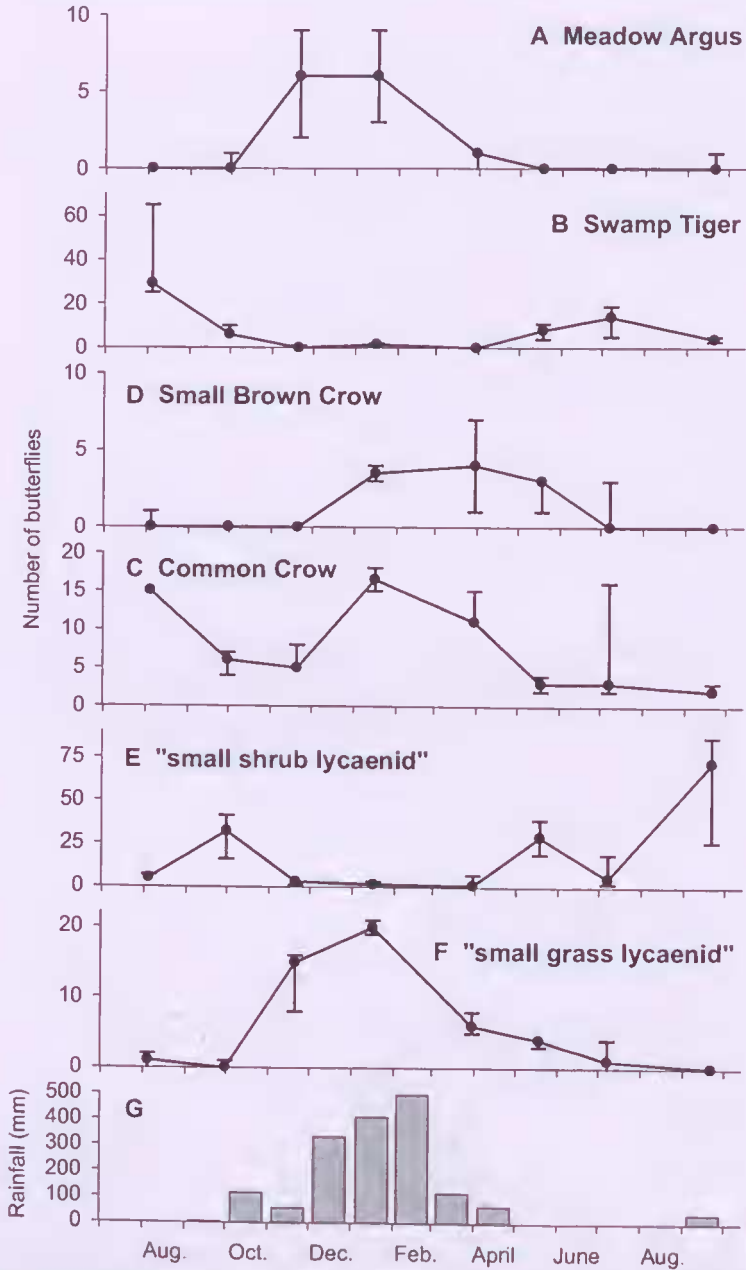


Figure 3. Variation over time in numbers (median \pm range) of six butterfly taxa (A-D – Nymphalidae; E-F – Lycaenidae) at Casuarina Coastal Reserve, and rainfall at Darwin Airport (G), from July 2008 to Sept. 2009. Note varying scales of abundance.

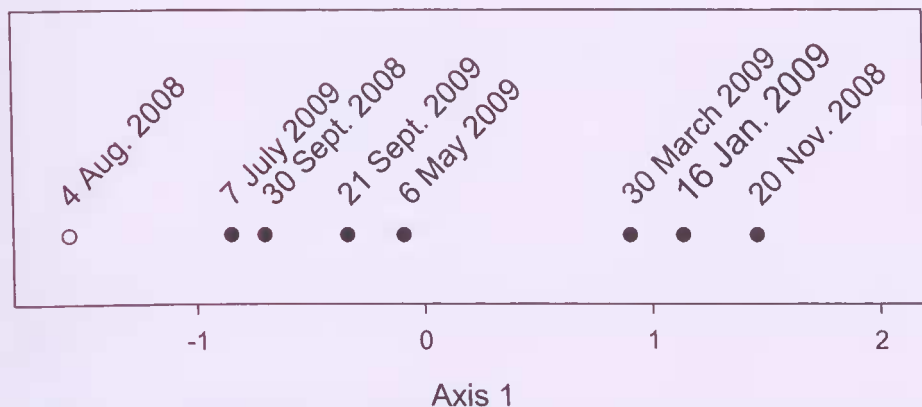


Figure 4. One-dimensional NMDS ordination of eight census periods based on assemblage composition (23 taxa). The median date of each census is shown. Final stress = 14.9, stable to one decimal place after 34 iterations.

Discussion

As one might anticipate in a highly seasonal environment where seasonality is primarily driven by rainfall, both species richness and the number of butterflies peaked during the wet season. This is expected for butterflies as the larvae of most species are dependent on fresh plant growth. The later peak and decline in the number of individuals compared to species richness may have occurred because populations of multivoltine species (those that undergo more than one generation per year) may accumulate with prolonged favourable conditions for breeding. Nevertheless, considerable butterfly activity persisted throughout the dry season. It is beyond the scope of this study to determine the biological basis for this continued activity: in theory, it could include persistence of diapausing adults, the ability to breed throughout the year (Jones & Rienks 1987; Braby 1995a), or migration into the study area (Dingle *et al.* 1999). Of note in this study is that taxa whose larvae feed, or mostly feed, on herbaceous plants, peaked in abundance in either the wet season (“grass-darts”, Meadow Argus, “small grass lycaenid”) or the wet-dry transition (“grass-yellows”). In contrast, all taxa with diffuse seasonal patterns have larvae that feed on shrubs, trees or woody vines, as do the two taxa that peaked during the dry season (Swamp Tiger, “small shrub lycaenids”). Although most woody plants in the region grow during the wet season, this is far from invariably so (Williams *et al.* 1997; Bach 2002).

My surveys are necessarily preliminary in that only a little over one annual cycle was investigated. It would be interesting to know how repeatable these patterns are – mosquito assemblages in the Darwin region exhibit strongly repeated annual cycles (Franklin & Whelan 2009). Further, my data suggests two taxa as prime candidates for

the investigation of non-adult diapause, "grass-darts" and Meadow Argus. To these may be added the White Albatross *Appias albina* (Braby *et al.* 2010), which is however, uncommon and thus less tractable as a research subject. None of these taxa are known or suspected to be migratory in the region.

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Appendix. Taxa/morphotaxa recognised in this study and their attributes.

This appendix is available at: <http://sites.google.com/site/ntfieldnaturalists/journal>.



Casuarina butterflies
(clockwise from above):
Lemon Migrant (TR),
Greenish Grass-dart (DB),
Orange Ringlet (DB),
Small Pearl-white (DB).



Right: Fuscous
Swallowtail
(TR).

Photographers:
DB = Deb
Bisa;
TR = Tissa
Ratnayeke.

